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(54) Hybrid synchronous machine with transverse magnetic flux.

(57) The machine structure provides smaller ohmic losses and a higher efficiency than in conventional motors with high torque per machine weight.

Each phase of the Hybrid Synchronous Machine with Transverse Magnetic Flux according to the invention is fitted with two rings (2,3) of ferromagnetic material which are cogged on the circumference on both sides, between which a magnetized disk (4) is inserted transversally to the direction of the stator winding (7), and the assembly thus formed is fixed to the rotor armature (1) with the cogged rings (2,3) being axially shifted between each other.

The described structure of the Hybrid Synchronous Machine with Transverse Magnetic Flux solves the technical problem of high density of transverse magnetic field in the air gap, and also effectively solves the problem of installing permanent rotor magnets by means of a magnetized disk (4) instead of individual inserted magnets.

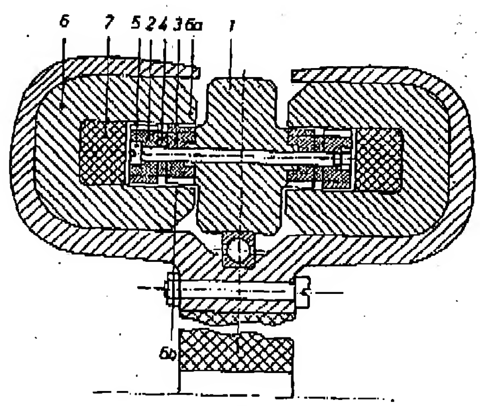

FIG.1

The subject of present invention is a Hybrid Synchronous Machine with Transverse Magnetic Flux whose structure is such that it provides smaller ohmic losses and a higher efficiency than in conventional motors with high torque per machine weight. The invention belongs to classes H 02 K 1/22 and/or H 02 K 1/28 of International Patent Classification.

The technical problem which is successfully solved by the present invention is to find a structural solution and to design such a hybrid machine with transverse magnetic flux in which a high density of magnetic field in the air gap can be achieved and in which permanent magnets are mounted so as to allow high tangential speed of the rotor.

The hybrid electric machines that have the stator winding running coaxially around the main axis of the machine are already known. The stator winding mounted in this way produces a transverse magnetic flux. A similar solution is described by H. Weh, H. May and M. Shalaby in their article "Highly Effective Magnetic Circuits for Permanent Magnet Excited Synchronous Machines", International Conference on Electric Machines, Cambridge MA., 13-15 Aug. 1990, p. p. 1040-1045.

The structural solution of an electric machine described in the above article offers a partial solution to our technical problem as far as ohmic losses are concerned, its winding being designed to produce transverse magnetic flux. The basic structural solution as described in this article has, due to the low density of the magnetic field of permanent magnets (these being installed centrally, one beside the other along the rotor circumference, so that magnetization runs in the radial direction) a feebler torque, while in an improved version, which is also described by the article, the magnets are arranged so as to produce an effect called "the concentration of magnetic flux". Such "concentration of magnetic flux" in the machines whose stator windings do not produce transverse magnetic flux is also described in German patent document DE 34 01 163.

In the structural solution described in the above article permanent magnets are placed in upright position (i.e. shifted by 90° with regard to the position of permanent magnets in the first case, so that the magnetization in the magnets runs in tangential direction). In this solution, the magnets are placed into or fixed to the recesses in the rotor.

Permanent magnets mounted in this way produce a magnetic field of greater density, and a machine with this rotor has a good torque per weight. A drawback in this solution is the mode of installation of the great number of permanent magnets; these can be glued or otherwise fixed to the rotor supporting ring. The position of permanent magnets being such that they can only be glued or attached by their smallest surface, this solution is not recommended for higher tangential speeds of the rotor. The fact that the magnets to be installed have to be magnetized in advance presents a certain technical problem, especially due to the great number of magnets and to the relatively high density of magnetic energy.

The Hybrid Synchronous Machine with Transverse Magnetic Flux which is the subject of this invention, consists (one phase) of two rings of soft magnetic material which are cogged on the circumference on both sides, between which a magnetized disk is inserted transversally to the direction of the stator winding, and the entire assembly thus formed is fixed to the rotor armature in such a way that the cogged rings are axially shifted between each other.

The invention will be further explained by an example and illustrated by drawings showing as follows:

Figure 1 cross-section of a two-phase Hybrid Machine with Transverse Magnetic Flux according to the invention;

Figure 2 axonometric view of a part of rotor assembly in partial cross-section;

Figure 3 cross-section of the Hybrid Synchronous Machine with Transverse Magnetic Flux according to the invention, variant II.

A two-phase version of the Hybrid Machine with Transverse Magnetic Flux according to the invention is shown in Figure 1. To each side of the rotor armature (1) an assembly is fixed consisting of two cogged rings (2, 3) of ferromagnetic material fitted with rotor poles (2 a, 2 b, 3 a, 3 b) and a magnetized disk (4). The cogged rings (2, 3) and the magnetized disk (4) can be held together by means of screws (5), as shown in Figure 2. The cogged rings (2, 3) in the assembly are placed so that their poles (2 a, 3 a) are mutually shifted, as shown in Figure 2. The same applies to the poles (2b, 3 b). The magnetized disk (4) is magnetized so as to produce a magnetic flux that can be directed either from the cogged ring (3) to the cogged ring (2) or in the opposite direction.

In the magnetic juncture with the cogged rings (2, 3) and the magnetized disk (4) lie stator poles (6 a, 6 b) of yokes (6) which encircle the stator winding (7). The number of stator poles (6 a) equals the number of rotor poles (2 a, 3 a) of the cogged rings (2, 3).

At a chosen moment of observation, when the stator pole (6 a) covers the rotor pole (3 a) and, due to the shift of the cogged ring (3) against the cogged ring (2), the stator pole (6 b) covers the rotor pole (2 b), a current starts running in the

winding (7) in such a direction that the density of magnetic field in the gap between the stator pole (6 a) and the rotor pole (3 a) of the cogged ring (3), and between the stator pole (6 b) and the rotor pole (2 b) of the cogged ring (2) decreases, while the density of magnetic field in the gaps between the stator pole (6 a) and the rotor pole (2 a) of the cogged ring (2) and between the stator pole (6 b) and the rotor pole (3 b) of the cogged ring (3) increases. Because of such momentanous magnetic state the stator poles attract the rotor poles in a position which is shifted by 1/2 of the pole's division with regard to the position at the chosen moment, so that in the end position of observation the stator pole (6 b) coincides with the rotor pole (3 b) of the cogged ring (3) and the stator pole (6 a) coincides with the rotor pole (2 a) of the cogged ring (2). At this moment the direction of current in the winding (7) inverts. This causes the rotor to move forwards, so that it reassumes the initially observed position of mutual covering of the rotor and stator poles. Through the change of current direction in the stator winding (7) the rotation of rotor is enabled, while the change itself can be achieved by electronic commutation.

In variant II (Figure 3) a Hybrid Synchronous Machine with Transverse Magnetic Flux is shown with the cogged rings (2', 3') designed on the stator armature (9). In the centre of each ring (2', 3') there is one half (7 a, 7 b) of coaxial winding (7). With such installation the Synchronous Machine according to the invention can be designed with an external rotor, where the salient poles of the rotor (8) are cogged along the entire axis and in the same pole division as the salient poles (2 a', 2 b', 3 a', 3 b') of the cogged rings (2', 3').

The described structure of Hybrid Synchronous Machine with Transverse Magnetic Flux solves the technical problem of great density of transverse magnetic flux and, with the introduction of the magnetized disk (4), effectively solves the problem of installing permanent rotor magnets.

Claims

1. Hybrid Synchronous Machine with Transverse Magnetic Flux,

   characterized in that

   the rotor or stator is in each phase fitted with at least one ring-shaped magnet which lies coaxially with the main axis of the electric machine, whereas on each side of the magnet there is a magnetically coupled ferromagnetic ring with two symmetrical circles of evenly spaced poles, while the stator or rotor has an equal number of salient ferromagnetic poles.

2. Hybrid Synchronous Machine with Transverse Magnetic Flux as per Claim 1,

   characterized in that

   depending on the number of phases, an adequate number of rotor assemblies is fixed to the rotor armature (1), the assembly consisting of cogged rings (2, 3) of soft magnetic material between which a magnetic disc (4) is placed, magnetized in the direction from the ring (2) to the ring (3) or in the opposite direction, while the stator poles (6 a, 6 b) of the yokes (6) are magnetically coupled with the rotor poles (2 a, 2 b, 3 a, 3 b) of the cogged rings (2, 3).

3. Hybrid Synchronous Machine with Transverse Magnetic Flux as per Claims 1 and 2,

   characterized in that

   the cogged rings (2, 3) are fitted on the outer circumference with rotor poles (2 a, 3 a), and on the inner circumference with rotor poles (2 b, 3 b), and the cogged rings (2, 3) tied together in a rotor assembly are tangentially shifted between each other by one half of a pole division.

4. Hybrid Synchronous Machine with Transverse Magnetic Flux as per Claim 1,

   characterized in that

   depending on the number of phases, to the stator armature (9) an adequate number of stator assemblies is fixed, consisting of cogged rings (2', 3') of soft magnetic material between which a magnetic disc (4') is placed magnetized in the direction from the ring (2') to the ring (3'), or in the opposite direction, while the salient poles of the rotor (8) are magnetically coupled with the stator poles (2 a', 2 b', 3 a', 3 b') of the cogged rings (2', 3'), and the winding (7) is divided into two symmetrical parts (7 a, 7 b) installed in the centre of each stator ring (2', 3').

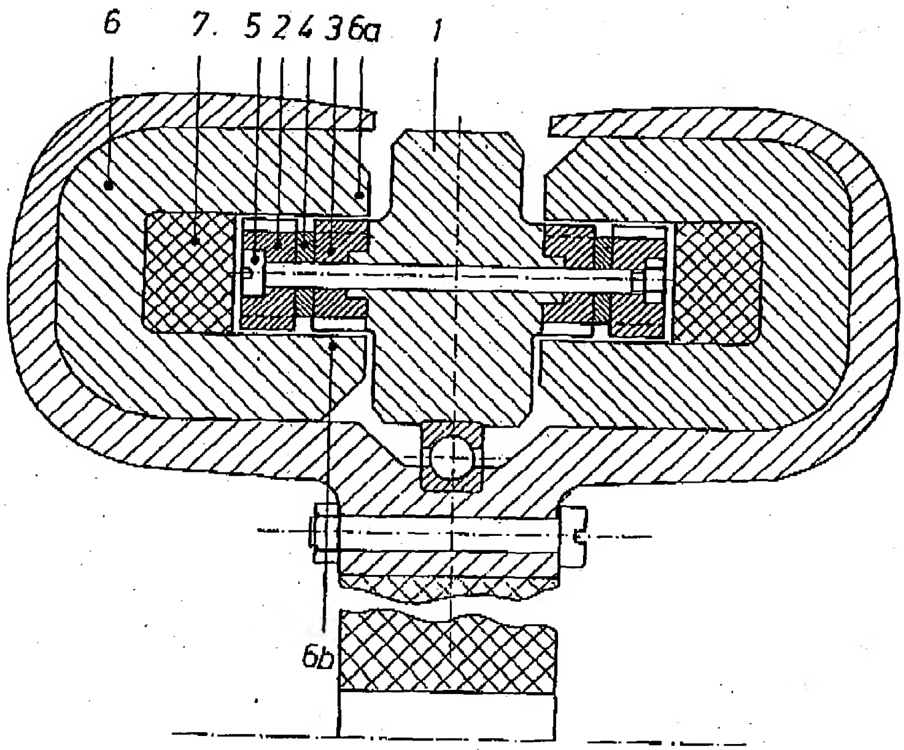

FIG.1

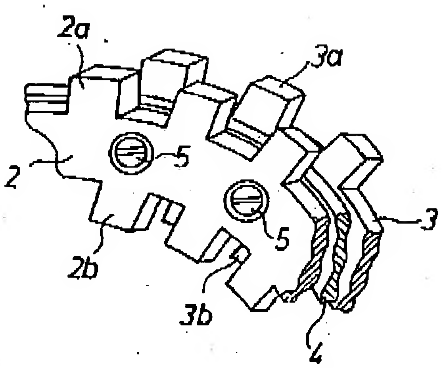

FIG. 2

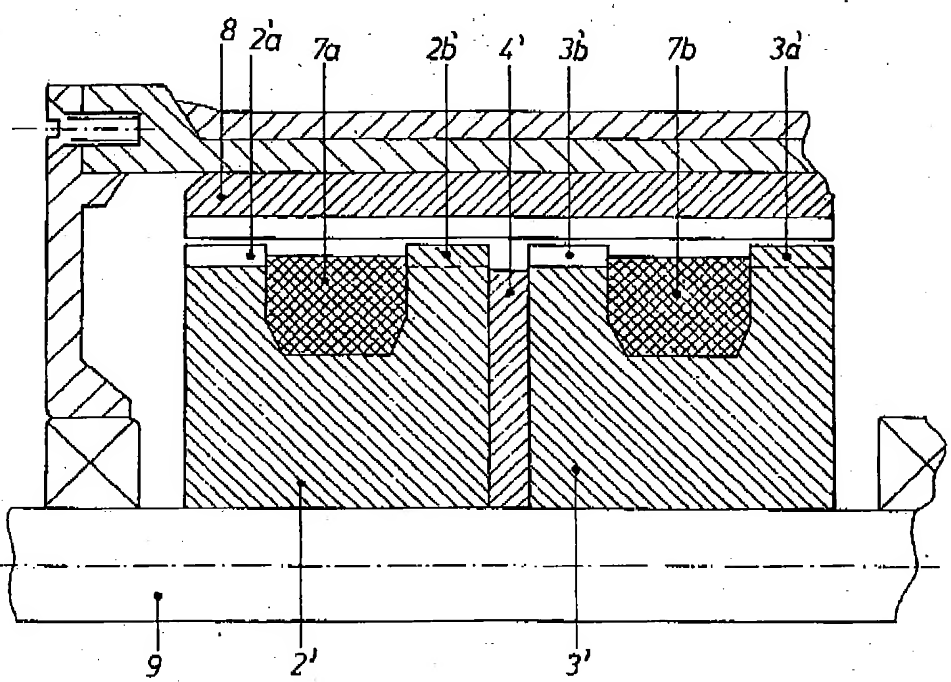

FIG.3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 11 9849

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	DE-U-8 711 725 (PAPST-MOTOREN) * page 21, line 7 - page 22, line 7 * * page 23, line 17 - line 26 * * figures 8-15 *	1,4	H02K21/12 H02K21/38
X	PATENT ABSTRACTS OF JAPAN vol. 5, no. 63 (E-54)(735) 28 April 1981 & JP-A-56 12 856 (NIPPON SAABO) 7 February 1981 * abstract *	1,4	
X	PATENT ABSTRACTS OF JAPAN vol. 9, no. 208 (E-338)(1931) 24 August 1985 & JP-A-60 70 958 (FUJITSU) 22 April 1985 * abstract *	1,4	
X	GB-A-2 052 176 (PHILIPS) * page 2, line 41 - line 81; figures 1,2 *	1,4	
X	GB-A-518 298 (BRITISH THOMSON-HOUSTON) * page 1, line 44 - page 4, line 52; figures 1-4 *	1,2	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
Y	US-A-4 459 501 (FAWZY) * column 3, line 40 - column 4, line 56; figures 1-5 *	1-3	H02K
Y	DE-A-3 626 149 (RITTER) * column 4, line 66 - column 6, line 1; figures 5-7 *	1-3	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 JANUARY 1993	TIO K.H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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